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Agricultural Research

New Ideas Bear Fruit...

Chester G. McWhorter, Distinguished Scientist of the Year

Throughout history, farmers have yanked them, stomped them, chopped them, buried them, poisoned them, and burned them, but to little enduring avail. The weeds persisted. Then along came scientists like Chester McWhorter, and things began to change.

We can thank McWhorter, a plant physiologist with the Agricultural Research Service, for the demise of millions of acres of weeds. During his distinguished career, he has proven himself among the most creative and productive of ARS scientists.

McWhorter, who joined the Agricultural Research Service in the mid-1950's, is the ninth recipient of ARS' highest scientific achievement award, Distinguished Scientist of the Year.

Among his premier achievements, McWhorter pioneered in the discovery that substances called surfactants help break down weeds' tough natural barriers to herbicides.

Surfactants changed the ground rules for herbicide application. Now the chemicals could be applied in far smaller amounts, with less frequency, and using different methods. For instance, diuron, originally a soil-applied herbicide, could for the first time be applied to weed leaf surfaces for selective weed control.


Chester McWhorter checking growth of johnsongrass, a serious weed in many areas.

A second McWhorter discovery paved the way for higher yields and easier harvesting of soybeans. He found that dinitroaniline herbicides work to selectively control johnsongrass growth from both rhizomes and seed in soybeans after 2 years of continuous use.

He has identified the most vulnerable stages of johnsongrass for weed control, an effort which has furthered knowledge of basic biology. In addition, his national research leadership has helped develop the most effective forms of weed control in soybeans.

McWhorter has also added several inventions to our weed-fighting weaponry: the recirculating sprayer, application of herbicides in foam and in wax bars to weeds in crops, subsurface application of herbicides with a blade device, and soil-injection of herbicides.

McWhorter's extensive travels on behalf of weed science have taken him around the world, from Austria to Australia, from Japan to Chile. He served as the leader of a three-man ARS team to universities, research centers, and industry of several European countries to identify new opportunities for cooperative research. By invitation of the Iraqi government, McWhorter presented a series of lectures on agricultural research needs. He's been an official delegate to the People's Republic of China to exchange information on soybeans.

A prolific writer, McWhorter has authored more than 200 publications for scholarly and popular audiences in the United States and abroad. He's also contributed leadership to the Weed Society of America; the Southern Weed Science Society; and the Council for Agriculture, Science and Technology.

In the early fifties, a 2-week temporary job assignment introduced the native Mississippian to what was to become his life's calling, weed science. His studies began at Mississippi State University, where he earned both undergraduate and graduate degrees in agronomy. McWhorter holds a doctorate in botany from Louisiana State University.

Regina Wiggen
Associate Editor

Agricultural Research

Cover: At the Appalachian Fruit Research Station in Kearneysville, West Virginia, ARS scientists are finding new ways to improve the nation's fruit industry. Here, soil scientist Michael Glenn uses a soil moisture probe to measure how much grass reduces the amount of water available to fruit trees. Photo by Keith Weller. (K-3275-8)

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DEPARTMENTS

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Kearneysville
Where New Ideas Come To Fruit

A harvest-time bonanza from the research orchards of West Virginia

Midst gently rolling farmland of the Shenandoah Valley, a 500-acre USDA research station presents a picture of rustic quietude.

But activity at the ARS Appalachian Fruit Research Station in Kearneysville, West Virginia, belies the languid setting. At this station, which was dedicated by Senator Robert Byrd in 1979, scientists conduct unique and innovative research.

Their goal is to develop the science, technology, and genetic base that will produce more and better fruit crops while minimizing disruption of the ecosystem.

"We run the gamut," says Stephen S. Miller, director at Kearneysville, "from developing new varieties, to training their growth habits, through developing mechanical means to harvest, and on to ensuring postharvest quality."

Integrating 9 scientific disciplines, 22 researchers work to improve the nation's deciduous fruit industry.

"We're fortunate to have modern laboratory facilities and thousands of fruit trees right here," says Miller, who doubles as lead scientist for fruit production research.

Over 250 acres are planted in apples, peaches, pears, apricots, and plums—even blackberries and a strawberry patch or two.

"Our work is diverse, bridging the gap between pure basic research and practical studies that solve real, everyday problems," Miller stresses.

Streamlining fruit production systems means not only improving the ways plants are bred, but also how orchards are managed throughout the year.

Horticulturists and agricultural engineers are devising ways to mechanically remove fruit from trees and cane crops such as blackberries.

And to protect crops before and after harvest, scientists are seeking new ways to fight disease and insects through breeding, biological control, and integrated pest management.

Biotechnology in Fruit Development

"Our aim is to understand and manipulate the regulation of the genes to determine their effect on fruit development," says Ralph Scorza, lead scientist who heads the Germplasm Enhancement unit.

The unit includes Ann Callahan, a molecular biologist, and research associate Peter Morgens, who are isolating peach genes that may affect fruit quality. Seth Mante (from Cornell University) and John Cordts, both tissue culture specialists, insert foreign genes into peach and plum cells, then regenerate these cells into trees.

These fruit quality genes, once successfully inserted into existing disease-resistant, insect-resistant or cold-hardy peach trees, may make unnecessary generations of traditional breeding.

Improving Cold Hardiness

Plant physiologist Michael Wisniewski hopes to unravel the mysteries of cold hardiness by looking at the structure of the cell wall.

Freezing temperatures can cause severe losses to the fruit industry. And there's not a clear understanding

KEITH WELLER

Plant physiologist Michael Wisniewski prepares peach twig for cold hardiness screening tests. (K-3285-7)

of how plant tissues acclimate to temperatures. The outer portions of buds (bud scales) will freeze while the deeper tissues don't. It's thought that the pores in plant cell walls may be the key. Using electron microscopy and a sophisticated computerized system he devised, Wisniewski discovered that the size of the pores in the membrane connecting cells determines at what temperature tissues freeze.

"This discovery will aid us greatly in developing winter-hardy stone fruit varieties," he says.

Cold Climate Nectarines

Since most nectarines are grown in milder climates like those of Georgia or California, growing them in West Virginia sounds unusual.

"This may soon change," says Scorza. "We've just released Earliscarlet, a high-quality, cold-hardy nectarine developed for the eastern United States."

Earliscarlet trees are vigorous and productive, bearing attractive, early-ripening, firm fruit; the flesh of Earliscarlet nectarines comes free of the stone. Tested in Byron, Georgia, since 1985, Earliscarlet has done well even when January temperatures have fallen to -6° F. Earliscarlet apparently resists bacterial spot *(Xanthomonas campestris* pv. *pruni)* and is free of major known *Prunus* viruses.

In addition to the nectarine, Scorza has released Bounty, a new peach variety with outstanding potential as a midseason, fresh-market fruit for the south-central and eastern United States.

"Bounty has excellent flavor, is large, firm, with flesh that doesn't brown even after being exposed to air for 24 hours," says Scorza.


KEITH WELLER

Tissue culture specialist Seth Mante checks growth of genetically engineered plum trees. (K-3279-11)


KEITH WELLER

To confirm the presence of a transferred gene, biologist Ann Callahan evaluates individual samples of plum leaf extracts. Brighter fluorescing samples suggest presence of the transferred gene. (K-3377-1)

New Cultural Practices

Weed scientist William V. Welker and soil scientist Michael D. Glenn observed that the conventional bare-soil strip beneath peach trees greatly increases the risk of erosion or pesticide runoff during heavy rains. So they developed an alternative orchard soil management system that not only reduces this risk, but increases orchard productivity in the process.

The system consists of establishing a vigorous stand of Kentucky 31 tall fescue and then killing it with a herbicide. The dead sod provides 100-percent ground cover under newly planted trees. Dead grass root channels provide a direct passage for water and rapid gas exchange in the soil. The sod prevents raindrop impact and soil surface sealing.

"Killed sod lowers soil temperature during the heat of summer and doesn't seem to increase risk of frost damage on cold nights," Glenn comments.

"Young tree growth increased 120 percent during the first three growing seasons, and initial fruit yields increased by 160 percent," Welker reports. No additional fertilizer was added to the soil.

This approach to orchard soil management promotes vigorous tree growth in the first 2 years, increasing yield potential. But, once the young tree has filled its allotted orchard space, growth should be regulated to reduce pruning costs.

To do this, Welker and Glenn reseed shallow-rooted grasses beneath the trees, leaving only a narrow herbicide strip. The reestablished sod continues to protect the soil surface and to reduce runoff potential while it maintains tree growth at an acceptable level.

"Our studies show that the low level of competition from this reestablished sod doesn't affect fruit size," says Glenn.

Changing tree growth habits is another way to increase production and save growers money. Standard peach trees are large (16 to 18 feet tall) with vigorous shoot growth that requires expensive annual pruning and fruit thinning. This is essential to maintaining large, high-quality fruit.

Reviving the Eastern Pear Industry

"There used to be a thriving pear industry on the East Coast," says horticulturist Richard Bell. "However, fire blight contributed significantly to its decline."

Attacking pear, apple, and ornamental rosaceous plants, fire blight is caused by the bacterium *Erwinia amylovora*. Plant pathologist Tom van der Zwet says this disease is the oldest, most serious, and most perplexing bacterial disease of these trees.

Van der Zwet, an international expert on fire blight, says it's aptly named. Blackened branches and leaves of blighted trees look scorched.

Although there's no cure, severe infection may be averted by spraying with streptomycin just as the flowers open and during the bloom period. A copper compound may be substituted if an orchard suffers from a streptomycin-resistant strain of the blight.


KEITH WELLER

Weed scientist William Welker uses infrared thermometer to check leaf temperature of peach tree growing in killed sod. Smaller tree (center) was planted in conventionally tilled soil. (K-3276-8)

"One significant problem with fire blight is that we don't fully understand the interaction among host, organism, and the environment," van der Zwet says. "The bacteria increase in numbers and spread rapidly when temperatures rise above 65° F. Moisture, either as rain, high humidity, or dew, is equally important."

To stay a step ahead of the elements, he has set up in a test orchard a hygrothermograph (records maximum-and minimum temperatures) and a simple rain gauge. This little weather station provides data to accurately predict when trees should be sprayed.

Now that the U.S. Environmental Protection Agency is considering a ban on the use of streptomycin as a pesticide, research to produce a genetically fire-blight-resistant pear variety has become more urgent.


KEITH WELLER

Research station director Stephen S. Miller (right) and plant pathologist Tom van der Zwet examine blackened branches and leaves of fire-blight-stricken pear tree. (K-3281-2)

"Within a year, we should be ready to introduce a pear that is highly resistant to fire blight," says Bell.

Cooperating scientists at U.S. universities and in Europe are evaluating the germplasm now.

Bell thinks these varieties will grow well in the eastern United States, and will also interest western growers.

He has also found eastern European germplasm that resists pear psylla *(Cacopsylla pyricola)*, the most serious insect pest of pears.

Fresh Market Apples

It's not just the work with peaches and pears that brings scientific disciplines together at Kearneysville. Apples for fresh market consumption must be hand-picked, a costly and labor-intensive operation.

Stephen Miller planted semidwarf Delicious apple trees and trained their growth to a modified open center form to experiment with a new, over-the-row mechanical harvester.

Developed by agricultural engineer Donald Peterson, the harvester straddles a row of trees. Moving continuously, it removes fruit by a shake-catch method. "We can now harvest three or four modified, open-

center trees a minute, with fruit grading nearly 90-percent fresh-market quality," Peterson says.

Peterson has also developed a rod-press harvester that pushes apples out of trees trained to form narrow, trellis-supported canopies. Delicious and Golden Delicious apples harvested this way for 2 years graded better than 90 percent US Extra Fancy/Fancy.

After the Harvest

If a large number of currently registered pesticides are revoked over the next 5 years, adequate replacement pesticides, particularly fungicides, would probably not be available for several major fruit and vegetable crops, according to the National Research Council's Board on Agriculture.

Aware of the growers' predicament, Kearneysville plant pathologist Charles L. Wilson started looking for alternatives to chemical control several years ago.

"We've primarily used fungicides to control postharvest diseases on fruit," he says. "Even when we apply acceptable fungicides, pathogens often become resistant."

Wilson feels that by breeding and selecting fruits and vegetables for certain desirable horticultural characteristics, we may have developed varieties more susceptible to postharvest diseases.

Wilson promotes the use of nature's own organisms against fruit diseases. He applies natural microbial inhabitants called antagonists to fruit surfaces to compete with disease-causing pathogens.

Along this line, Wilson and an Israeli scientist, Edo Chalutz, have patented a yeast that controls several postharvest rots on a wide variety of fruits. This yeast occurs naturally on fruit and is commonly found in food. Negotiations are underway for commercial development.


KEITH WELLER

Digitized apple images made at different wavelengths help agricultural engineer Bruce Upchurch develop image-processing techniques that will show the degree of damage even in hidden bruises. (K-3278-2)

"Now we can artificially introduce antagonists to fight postharvest pathogens," Wilson says. "Next we'd like to learn how to promote and manage natural antagonists that exist on fruit surfaces."

Wojciech J. Janisiewicz, plant pathologist, is pioneering this approach. Working with ARS chemist James M. Roitman in Albany, California, Janisiewicz isolated an antagonist bacterium, *Pseudomonas cepacia*, from apple leaves and fruit. It produces an antifungal compound, identified as pyrrolnitrin, that controls blue mold and gray mold on apples and pears.

When immersed in a harmless water dip containing Janisiewicz's antagonist, Golden Delicious apples and Bosc pears with small surface cuts completely resisted the molds. These molds are the worst diseases of picked apples.

In December 1988, Janisiewicz signed an agreement with the Fujisawa Pharmaceutical Co., Osaka, Japan, to produce the compound for large-scale tests.

EcoScience, Inc., Amherst, Massachusetts, a firm that develops and commercializes environmentally safe products for biological control, is interested in commercializing pyrrolnitrin-producing bacterium and two other antagonists that Janisiewicz has discovered.

Patent for Janisiewicz's process to protect fruit with pyrrolnitrin-producing bacterium is pending.

Through Computer Vision

Postharvest quality is more than a matter of disease control. Using a camera connected to a computer, agricultural engineer Bruce L. Upchurch is developing ways to detect watercore and visible and invisible bruises on apples.

Since watercore doesn't show up on the surface of fruit, the only way to detect the disorder to date without slicing is to visually inspect a random sample of apples with a hand-held watercore meter. If watercore is found in the sample, a grower can suffer serious economic loss; the entire lot will be downgraded.

However, these apples are still marketable if sold soon after harvest.

Upchurch and Cornell University's James A. Throop are developing a way to detect watercore by directing a ray of light from an ordinary lightbulb through the apple calyx and viewing the stem end with a camera. More light passes through a watercore-affected apple because of the free fluid in the tissue.

"We can't detect the degree of the disorder," Upchurch comments, "but this method could be used in an automatic sorter to evaluate each piece of fruit for watercore. With some modifications to existing equipment to position the fruit upright, the technique could be used with apple-handling equipment already in most packinghouses."

Upchurch and Throop are devising other ways to ensure quality of apples. Using spectrophotometry, which breaks down a light beam into individual wavelengths, they measure light reflectance properties of healthy and bruised apple tissue.

"Bruised tissue has a lower reflectance than nonbruised," says Upchurch. "This decreased reflectance could be due to increased light scattering and/or absorption within the bruised region."

The system, using cameras with optical filters and a computer program, may increase the "vision" of automatic sorting equipment now used by industry.

Although commercial use for these techniques may be down the road a bit, Kearneysville has shown that the potential exists to use nondestructive sensing to sort good fruit from bad.—By **Doris Sanchez,** ARS.

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Another way to increase production and save money is to find the most appropriate tree shape.

Standard peach trees are large (16 to 18 feet tall) with vigorous shoot growth that requires expensive annual pruning and fruit thinning. This is essential to maintaining large, high-quality fruit.

Horticulturist Ralph Scorza is working on several different peach tree growth habits that could have a significant impact on the fruit industry. Obviously, more work awaits plant physiologists, breeders, and horticulturists before these forms are commercially available. But when they are, growers will have a "choice of tree forms to fit their particular needs and will [have] greater potential for more profitable, easier-to-manage orchards," Scorza says.

Semidwarf trees are a cross between the dwarf and compact, somewhat smaller than standard trees. They may be most suitable for commercial peach growers. Small size eliminates use of ladders in the orchard and allows for higher planting densities and favorable light penetration. Scorza is working with peach breeders in Italy, developing and testing new semidwarf selections.

Dwarf trees rarely reach more than 8 feet. Their short internodes and large leaves make a dense canopy. These can be grown in home orchards in northern and mid-Atlantic States, if protected from extreme cold temperatures. Current varieties are probably better suited to California growing conditions, but dwarf varieties for the Eastern United States will be developed.

Compact trees range in size from 6 to 9 feet. Their canopy is not quite as dense as dwarf, allowing more light penetration essential for fruiting. More research is needed to breed a variety that produces fewer side branches.

Pillar trees are noted for narrow branch angles that result in an upright, column shape. About 12 feet tall, they can be crossed with standard, compact, or dwarf varieties for different branch angles and heights. Scorza is collaborating with researchers at the University of Bologna, Bologna, Italy, to develop a pillar tree for high-density production. Narrow canopy also makes it ideal for small gardens, and columnar form lends itself to interesting landscaping. Over 900 pillar trees can be grown per acre compared to about 132 standard-size peach trees.

Can Crops Tolerate Acid Rain?

Many farm crops, from lettuce to winter wheat, do not appear to suffer under acid rain, according to research at the ARS Air Quality-Plant Growth and Development Laboratory in Raleigh, North Carolina.

Botanist Denis T. DuBay, plant pathologist Allen S. Heagle, and plant physiologist Walter W. Heck exposed 216 varieties of 18 crops to simulated rain many times more acidic than what now falls in the eastern United States.

The simulated acid rain caused no significant injury, nor did it reduce growth in most species.

"Variation among cultivars means . . . we may be able to breed hardier strains if we need to."

Walter W. Heck, ARS plant physiologist

Acid rain is precipitation that has picked up airborne pollutants such as sulfur dioxide and nitrogen oxide, which are present in exhaust from factory smokestacks and automobiles.

Such pollutants make rain more acid, decreasing the pH (a logarithmic scale measuring acidity, with pH 7.0 being neutral) to as low as pH 3.0. Rain in North Carolina averages about pH 4.4.

DuBay, Heagle, and Heck first watered their test crops with simulated acid rain at pH 2.5, two orders of magnitude more acid than average rainfall, for a single exposure lasting 1 hour.

"Only in the most sensitive varieties was growth rate reduced," Heck says.

Tomatoes, eggplant, snapbeans, cotton, peanuts, and soybeans were the only crops whose leaves showed damage of more than 5 percent after the 1-hour exposure. The most sensitive variety of tomato had as much as 24 percent of its leaf area damaged by the single exposure.

Injured leaves had small bleached or burned spots, usually where water droplets had remained on the leaves for an extended time or where a large volume of water had flowed over the surface.

At the other end of the scale, potatoes, corn, lettuce, winter wheat, orchardgrass, melons, fescue, cucumbers, alfalfa, clover, and squash all had less than 2-percent leaf damage, DuBay says.

The researchers also looked at whether chronic exposure to acid rain, for up to 15 days at a time, had an effect.

"We were hoping to find that the results of chronic and acute exposure could be correlated, allowing us to use the much quicker 1-hour exposure in the future to screen varieties for sensitivity to acid rain," Heck says.

Lettuce, tomatoes, soybeans, and winter wheat were selected for the series of chronic exposures because they were among the most sensitive and the most tolerant crops in the acute tests. As hoped, the two crops most injured in the acute tests, tomato and soybean, also suffered the greatest growth reductions in the chronic tests. Winter wheat and lettuce, the two crops least injured in the acute tests, showed little or no growth reductions.

Leaf damage among tomato varieties at pH 3.0 ranged from a high of 45 percent of the leaves injured for Castlepeel II down to Walter Villemarie 744, with only 5 percent. With soybeans, the damage ranged from 9 percent for Vinton 81 to 24 percent for Corsoy.

ROB FLYNN

Botanist Denis Dubay takes a sample of the acid rain solution being tested on soybean plants. Each table top has an open dish to collect the rain mixture for laboratory analysis. (K-3314-1)

"Variation among cultivars means that for susceptible crops, we may be able to breed hardier strains if we need to," Heck says.

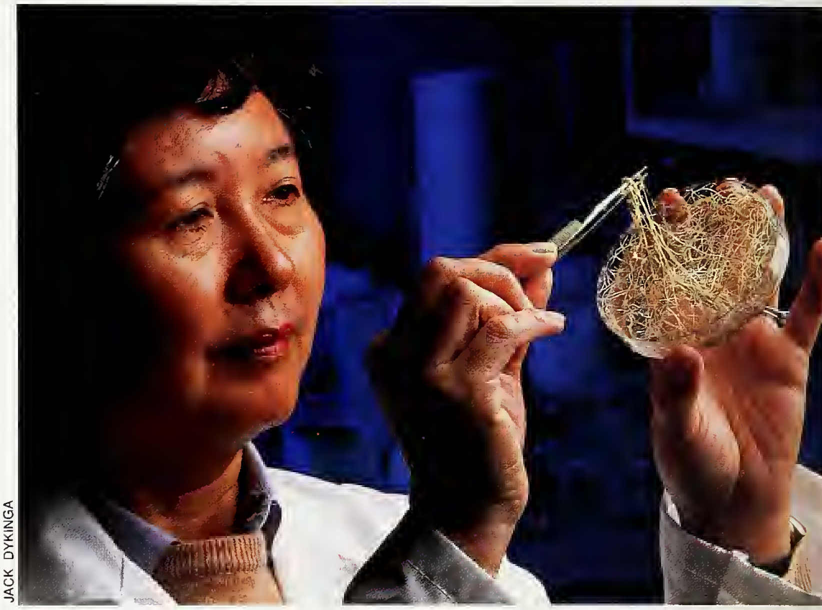
But the most significant finding is that pollution danger to crops is more likely to be from sources other than acid rain, Heagle says, sources such as ozone and ultraviolet radiation.

—By **J. Kim Kaplan,** ARS.

Allen S. Heagle and Walter W. Heck are at the USDA-ARS Air Quality-Plant Growth and Development Laboratory. Denis T. DuBay is with the research faculty, Department of Botany, North Carolina State University. The mailing address for all three is 1509 Varsity Drive, North Carolina State University, Raleigh, NC 27606 (919) 737-3311. ◆

Underground Allies of Plants

Friendly fungi that live with plant roots can deliver nutrients and water plants aren't able to get on their own.



JACK DYKINGA

Plant physiologist Sui-Shang Hua removes a tiny portion of hairy carrot roots for propagation on fresh medium. (K-3374-1)

Helpful microorganisms known as mycorrhizal fungi send out finely branched, threadlike hyphae from plant roots that act as miniature pipelines for nutrients.

Hyphae can penetrate soil spaces where even the finest plant roots can't grow, says Gabor J. Bethlenfalvay of ARS' Plant Development-Productivity Research unit, Albany, California.

The fungi are so prevalent in the world's soils that most crop plants normally have them growing in their roots. But growers who want to get the most work out of these microorganisms, says Bethlenfalvay, should consider the welfare of the fungi when applying fungicides, fertilizers, or other chemicals that make life harder for these soil dwellers.

Scientists credit the fungi with diligently performing a long list of other useful chores: strengthening erosion-prone soils, helping plants live on soils high in toxic metals, keeping plants alive during drought by extracting precious moisture from soil pores, and boosting plants' ability to capture vital energy.

One of the most important jobs the fungi perform for today's growers is to help them cut back on phosphorus fertilizers. Those chemicals can pollute groundwater. According to Bethlenfalvay, mycorrhizal fungi do "an excellent job" of shuttling phosphorus—as well as zinc and copper—from soil to host plants.

Researchers in the Albany unit are snooping into the secret life of these fungi. Their research may produce new tactics for consistently getting superior results from these remarkably effective organisms. Here's a brief look at their work.

Erosion Stoppers

Scientists praise mycorrhizal fungi for helping fight erosion, but no one knows for certain how the fungi do that job.

"We know that the fungi dramatically stimulate growth of plant roots, and that those roots help bind soil grains into an erosion-resistant matrix," says Richard S. Thomas.

But the slender hyphae may actually do as much—if not more—than roots to help hold soil in place. To check, he's comparing the erosion

TIM McCABE

To calculate water lost from leaf surfaces, plant physiologist Gabor Bethlenfalvay (foreground) and biophysicist Richard Thomas measure the size of soybean leaves. (K-2844-8)

potential of soil that contains roots and mycorrhizal hyphae with soil that has either roots, or hyphae, or neither. "If the hyphae are keeping the soil particles together," Thomas says, "perhaps we should be searching for fungi that put out a luxuriant growth of these filaments."

The fungi could also be a boon to replanting lands left barren from mining, or perhaps for raising crops on soils high in manganese—a common problem in parts of the South, says biologist Raymond L. Franson. His preliminary experiments with soybean plants grown in high-manganese soil indicated that seedlings teamed with the fungi bypassed manganese toxicity, while those living without the micro-organism took up toxic amounts of the mineral.

Franson speculates that the fungi may reduce the amount of special natural chemicals plants would otherwise exude from their roots. Normally, those chemicals would convert manganese into a form plants would all too readily absorb.

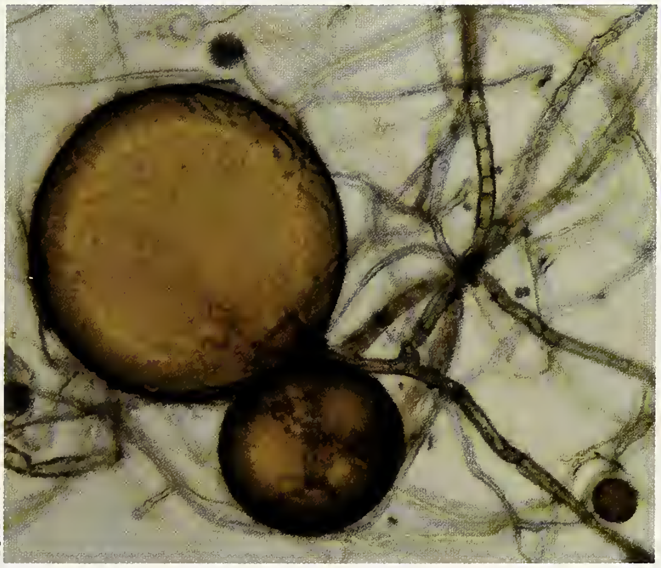
Unlike manganese, which most plants need only in very tiny amounts, the mineral phosphorus (in its phosphate form) is a nutrient most crops need in large doses. Plants use it in many of the chemical reactions that occur when they convert sunlight into food, according to chemist Milford S. Brown.

His greenhouse experiments showed that soybeans living with the fungi needed only half as much phosphorus to work at the same photosynthetic rate as counterpart plants not colonized by the microorganisms.

Similar greenhouse experiments with nitrogen fertilizer showed that the colonized plants needed about 25 percent less fertilizer to conduct photosynthesis at the same rate as uncolonized seedlings.

Most mycorrhizal fungi sold commercially are packaged in clay chips or bags of dirt that contain spores, or roots the fungi have colonized. But the supply is limited and expensive. In fact, cost is frequently cited as the reason growers of "single-season" crops such as corn, barley, rice, and soybeans don't use the fungi, and rely on phosphorus fertilizers instead.

But nurseries that sell fruit trees, or rootstock for nut trees and grapevines, generally add the fungi to nursery beds and pots. These crops are meant to live for decades in orchard or vineyard and need the extra advantages mycorrhizal roots can provide over their lifetime.



SUI-SHANG HUA

A large round mother spore of *Glomus mossease* produces a hyphae network and baby spores. (K-3375-1)

Growing Stubborn Fungi

Mycorrhizal fungi might be more affordable if scientists could find a way to get the fungi to multiply in test tubes. Then, companies could easily raise huge quantities of the microorganisms.

Right now, the type of fungi that lives with the widest range of plants—known as endomycorrhizal fungi— simply won't grow without plant roots.

Among the scientists trying to coax stubborn endomycorrhizal fungi into multiplying—minus roots—is plant physiologist Sui-Sheng T. Hua. The key, she says, is to find out the special interaction that takes place when hyphae, sprouting from the fungi's "mother spore," meet a plant root. "Some vital exchange takes place," she says. "Until we find out what it is, we probably won't be able to grow mycorrhizae in the laboratory except on living plant roots."

In a successful interaction of root and mycorrhizal fungi, the hyphae proliferate. They grow out of the root and into the soil, absorbing and shunting nutrients or moisture back to the root. Spores that form in the soil on the tips of some of these new hyphae will eventually start the cycle all over again.

In most laboratory attempts to grow endomycorrhizal fungi without host roots, Hua says, the fungi get to a certain point, then simply stop developing. But no one knows why.

What do roots provide that the fungi must have? To find out, Hua is using masses of carrot roots that thrive in petri dishes. The roots themselves are a biological oddity in that they grow without the rest of the carrot.

Scientists have known how to genetically engineer roots to perform this trick since about 1984. Hua says the roots are ideal for her research because she can grow them without bothering with soil or carrots. "I can focus on just the root and the fungus," she says. "This approach is much cleaner than growing plants in soil, then sieving the dirt to rescue hyphae and spores. I don't have to contend with other microorganisms that live in soil and could contaminate my experiments."

BARRY FITZGERALD

Plant pathologist Stanley Nemec examines root development of citrus plants growing without mycorrhizae. Similar plants on the right have benefitted from a mycorrhizal infection. (K-3324-2)

Hua estimates it may take at least 5 years before hardy, healthy, affordable endomycorrhizal fungi will be produced in test tubes.

That research might be helped along by the recent discovery of five unique proteins in soybean roots that are colonized by mycorrhizal fungi. Raymond S. Pacovsky, microbiologist with the Plant Development-Quality Research unit at Albany, says the new proteins—or endomycorrhizins—probably play an important role in the bonding of root and fungus.

What if biotechnologists could get the mycorrhizal fungi to produce these special proteins without help from roots? "If that happens," Pacovsky says, "the fungus might be able to grow on its own, with no roots needed.

"The key here is to find, and turn on, the genes that cue the fungus to produce these special proteins. Techniques of modern biotechnology might someday make it possible."

In addition to the Albany-based scientists, other ARS researchers are probing the mysteries of mycorrhizal fungi.

• When plants are grown indoors in liquid-filled, shallow plastic trays, with roots trailing in the bath of water and nutrients, mycorrhizae flourish, says James R. Ellis, microbiologist at Lincoln, Nebraska. But this squeaky-clean and potentially efficient method for mass-producing the fungi, developed elsewhere, still needs more work, he says. A question that Ellis intends to answer: What's the best mix of nutrients to use, to help mycorrhizae thrive?

Ellis is interested in the interaction of the fungi with crops such as corn and soybeans. In preliminary experiments, corn plants were highly dependent upon the fungi—a surprise in view of the fact that the plants were living on high-phosphorus soils. "Until now," explains Ellis, "it was presumed that whenever you have adequate phosphorus in the soil, mycorrhizal fungi won't have a very big effect on these crops."

• One of the fastest and easiest ways to get the fungi to colonize roots of young trees in Florida citrus orchards might be to plant intended orchards a year in advance with local grasses such as Pensacola bahia, or coastal bermudagrass.

Just before citrus seedlings are transplanted to the orchard, the grass can be plowed under, and fungi sending out exploratory hyphae from the grass may colonize roots of the young trees, says Stanley Nemec at Orlando.

That's what happened in nursery studies with orange seedlings and these grasses, he says.

With Herbert H. Bryan of the University of Florida, Nemec has tried another tactic, called fluid drilling, on tomatoes. The researchers made a mix of partially germinated tomato seeds, a gooey gel, and soil containing roots colonized with the fungi, then packed that mixture into small holes drilled in the field. Combining the germinating seed with mycorrhizal fungi "significantly increases chances that the little plants will be colonized by the fungi," says Nemec. "Fluid drilling really works."

• Distinguishing one species of mycorrhizal fungi from among the

hundreds of others in the world sometimes takes the specialized skills of a rare breed of taxonomists. Those scientists must painstakingly inspect individual spores of the fungi under high-power microscopes.

To make it easy, fast, and practical for scientists and growers to know which fungi they have in their laboratory or on their farm, Sara E. Wright at Beckley, West Virginia, and colleagues developed what they believe is the first monoclonal antibody probe for identifying a mycorrhizal fungi. The test offers the surest way yet to readily recognize *Glomus occultum*, a species common in acidic soils of West Virginia and much of the eastern United States, says Wright.

She now wants to develop a similar test for another species, *Glomus intraradices* so growers who buy the fungus have a quick way to know if it's on roots of their crop. After that, Wright wants to fine-tune the antibody test so it will indicate how much colonization has taken place. Such a test would reveal the top-performing species and strains when tested with different host plants, climates, or soils.

KEITH WELLER

Microbiologist Patricia Millner removes mycorrhizal fungi from liquid nitrogen storage at about -196°C for viability tests. (K-3376-1)

• At Beltsville, Maryland, Patricia D. Millner is checking out another method to unerringly identify look-alike fungi. She's working with a sophisticated technique that compares genetic material extracted from the core of each fungi's being—the DNA in its cells.

The approach, known as restriction-fragment-length polymorphism, has already been used to circumvent taxonomical nightmares posed by physically similar but genetically different varieties of highly hybridized crops such as tomatoes. The approach may be a surefire way to recognize not only individual fungal species but also the diverse strains within a single species. That's important, says Millner, because some strains work noticeably better than others.

Millner is also intrigued with the potential for storing mycorrhizal fungi at very low temperatures in liquid nitrogen. Hopefully, this cryopreservation would keep the microorganisms alive for months—if not years.

• A cutting of poinsettia, pear, or grape will have a better chance of developing into a hardy plant with a strong, healthy root system if mycorrhizal fungi are there to help, says plant pathologist Robert G. Linderman at Corvallis, Oregon. He is using these species and others in preliminary experiments with the fungi. Landscape plants, too, such as cherry laurel or kinnikinnick—a popular ground cover—benefit from fungal alliances: in greenhouse tests,

MICHAEL THOMPSON

Measurements of the photosynthetic rate in these poinsettia leaves indicate that mycorrhizae reduce drought stress. (K-3331-14)

90 percent of the kinnikinnick stems grown with the fungi developed roots, whereas only 10 percent of those planted without the microorganisms did.

Tiny seedlings of Douglas-fir, pines, and spruce, when taken out of cold storage and planted in nursery beds or forests, also develop better root systems if helped by the fungi, he says.

Linderman and colleagues now want to find out why this happens, so they can more easily pinpoint mycorrhizal species that are most helpful to cuttings and transplants.

• Plant physiologist John R. Potter and colleagues at Corvallis are trying to solve the puzzle of why plants colonized by mycorrhizal fungi are more drought resistant. Once scientists figure out the mechanism, Potter says, that might pave the way to a better and faster method for finding fungi that do this job the best.—By **Marcia Wood,** ARS.

If you are interested in contacting scientists mentioned in this article, write or telephone the Editor, Agricultural Research, Bldg. 005, Beltsville Agricultural Research Center-West, Beltsville, MD 20705 (301) 344-3280. ◆

Collecting Ryegrass in the Soviet Union

ARS scientists touring the steppes of the U.S.S.R. may save U.S. cattle and sheep producers millions of dollars.

Using seeds of wildrye and other plants collected in the Soviet Union, plant geneticist Kay H. Asay and co-researchers at the ARS Forage and Range Research Laboratory in Logan, Utah, are breeding new, taller perennial ryegrasses that could enable animals to graze 2 months longer than usual each year.

This would cut down on winter feeding, often a rancher's greatest expense. Hay runs anywhere from $70 to $100 a ton plus the labor of hauling and putting it where the animals can get it.

"Hybrids between native wild ryes and selected species from the U.S.S.R. are outstanding," says Asay. "These plants often grow to almost 7 feet. Their leaves cure well and protrude above the snow so cattle and sheep can graze them well into the winter. They provide better-quality feed for livestock during that period than most other forages available to grazing animals. They are also a boon to wildlife.

"These are dryland grasses," says Asay, "and that means they thrive on western ranges. Besides providing cool-season forage, they stay green later, reducing fire hazards."

Research geneticist Kay Asay (left) talks with a Soviet farmer (on horseback) about grasses that are native to the Altai region in the USSR. Next to Asay is his interpreter, Sergey Dadurin.

In August 1988, Asay and ARS plant physiologist Douglas A. Johnson and plant geneticist Michael D. Casler, professor of agronomy at the University of Wisconsin, collected a number of wild rye species from parts of the Soviet Union that have previously been off-limits to foreign scientists.

Some of the plants brought back will be grown to produce more seed, which will then be stored in facilities maintained by the National Plant Germplasm System. Seed will also be used as breeding stock to improve plants grown in the United States.

"This kind of exploration provides us with a vast genetic reservoir that could be used to improve cereal crops," says ARS plant geneticist Kevin B. Jensen. "It's an opportunity for us to put together genetic combinations of grasses that have never before existed."

The Logan inventory of ryegrasses, wheatgrasses, and related species is the world's largest living collection of these grasses. Of the 325 species in this plant tribe kept in Logan, about 250 are perennials, including many of the world's important forage grasses.

While in the Soviet Union, Asay, Johnson, and Casler made about 600

DOUGLAS JOHNSON

seed collections, representing nearly a hundred species of forage grasses and legumes. National Geographic magazine writer Robert Rhodes and photographer Lynn Johnson accompanied the researchers.

During the month they spent collecting the seeds, the explorers crossed four time zones and traveled well over 5,000 miles with scientists and an interpreter from the Vavilov All Union Institute of Plant Industry in Leningrad who helped plan and organize the expedition.

The Institute maintains a large seed collection and has shown a willingness to exchange plant materials with scientists from Logan and other U.S. locations.

"The 1988 expedition was an unqualified success. We made excellent contacts with scientists and administrators at major agricultural research institutes. Compared to a visit 6 years earlier, we found a much more open attitude for exchange," says Asay.

"People from state farms and research institutes along the way were also extremely helpful and often assisted in collecting. In addition to staff from the Vavilov Institute, plant scientists from research institutes in Siberia and Kazakhstan accompanied us. The hospitality was fantastic!"

According to Johnson, "Our Soviet hosts organized a camping expedition to the Altai Mountain region, about 100 miles west of the Mongolian border. This allowed us to visit with local residents and learn more about the natural vegetation in the collection area. People we met there were always interested in U.S. farming methods, our families, and our lifestyle.

"We spent one night in a herdsman tent called a yerta on the Kazakhstan Plain. A train trip from the large industrial center of Novosibirsk to Alma Ata, thought to be the original home of the apple, took 36 hours and allowed us to make some valuable seed collections at stops along the way."

But there are other sides to botanical exploration. "Although we found it a rare opportunity to gather prize specimens available nowhere else in the world, it was a grueling schedule," says Asay. "Once, after collecting seeds with our Russian colleagues for almost 16 hours, we had to catch a 2 a.m. flight only to land and find a fresh team of Soviet researchers waiting to take us to the next collecting site."

DAN MILLER

Back home in the United States, Asay examines hybrids made by crossing native American wild ryes with wild rye from the Soviet Union. (K-3369-1)

In August 1989, another expedition was made to the Soviet Union by Jensen and plant geneticist Douglas R. Dewey. More than 420 accessions of forage grasses and forbs were collected in this expedition which was sponsored by the Central Siberian Botanical Garden of the U.S.S.R. Academy of Sciences.—By **Howard Sherman,** ARS.

Kay H. Asay, Douglas A. Johnson, and Kevin B. Jensen are at the USDA-ARS Forage and Range Research Laboratory, Utah State University, Logan, UT 84322-6300 (801) 750-3066. ◆

Chinese Pigs May Perk Up Production

They have more wrinkles than a raisin and faces only a sow could love. But the 144 Chinese pigs now in the hands of Midwestern scientists may be a beautiful opportunity to improve U.S. breeds.

The Chinese pigs' particular charm lies in their prolificacy. The breeds imported—Ming, Meishan, and Fengjing—average 3 to 4 more pigs per litter than do U.S. swine.

"Even if the genes from these breeds are not used in commercial swine production, these animals can be very useful to scientists as experimental models."

Roger J. Gerrits, ARS national program leader for animal production.

Scientists at Iowa State University, the University of Illinois, and the Agricultural Research Service's Meat Animal Research Center at Clay Center, Nebraska, will conduct at least 5 years of research to evaluate the animals and determine if they should be released for use by the U.S. swine industry.

Each university and ARS will fund and conduct its own research program, but projects at each location will be coordinated. Provisions have also been made for the exchange and sharing of germplasm among the three locations in case of a disease outbreak or other unexpected losses.

The overall objective of the research is to cross the Chinese breeds with U.S. breeds to increase litter size while maintaining the quality and lean yield of pork. U.S. geneticists have estimated it would take as many as 25 generations of conventional selection to increase the litter size of the average U.S. swine breed to that of the Chinese breeds.

The Asian porkers arrived in the United States from the People's Republic of China on March 26 and spent 120 days in quarantine at Fleming Key, Florida, home of the Harry S. Truman Animal Import Center. The swine had already spent 60 days in quarantine in China.

On their release from the Florida facility in late July, they were divided equally by breed and families within breeds among researchers at Iowa State University, the University of Illinois, and Clay Center. ARS served as the contractor for the importation, but the agency and the two universities shared equally in the costs.

Plans to import Chinese breeding swine into the United States for research can be traced back to 1978 and the visit of then-Secretary of Agriculture Bob Bergland to China.

From that visit, a general cooperative agreement was developed between USDA and the PRC for the exchange of scientists, plant and animal germplasm, and scientific information. The final agreement for importation of the breeding swine was signed in the United States by representatives of ARS and the Chinese National Animal Breeding Stock Import and Export Corporation on September 28, 1988.

BRUCE FRITZ

Originating in the Heilonjong Province of northeastern China, the Ming breed of swine reach puberty at about 4.5 months of age. (K-3380-8)

China represents an exceptional reservoir of unexplored swine germplasm, possibly containing more than 100 pig breeds or types. Domestication of swine in that country can be traced back 6,000 to 7,000 years.

The long history of domestication, unique culture, specialized production methods, and geographical isolation from other major pork-producing countries have resulted in the development of Chinese swine breeds with unusual characteristics.

BRUCE FRITZ

ARS technician Ronald Pooschke gets acquainted with a Chinese Fenjing boar at the U.S. Meat Animal Research Center at Clay Center, Nebraska. (K-3383-1)

These characteristics reflect the presence of some unique genes or the increased frequency of genes that are rare in other breeds. The three breeds selected for importation into the United States are noted not only for large litters and early maturity, but may also be more resistant to some diseases and may have a

greater ability to utilize high-roughage diets, scientists say.

The Meishan and Fengjing breeds are representative of the Taihu group of breeds originating in the region around Shanghai. ARS imported 33 Meishan boars, 66 Meishan gilts, and 24 Fengjing boars.

Both Meishan and Fengjing swine reach puberty at about 3 months of age and average 14 pigs per litter in their first 2 litters and 17 thereafter. The Meishan and Fengjing pigs have large bellies and large, fleshy wrinkles on their faces.

Growth and backfat information on these pigs provided by the Chinese has been described as difficult to interpret because of the unique feeds and management used there.

But research results from France, where a small group of Taihu breeds was imported about a decade ago, indicate market pigs that are one-quarter Meishan have about 4 percent less lean than do the typical French Landrace and Large White breeds.

The Ming breed, originating in the Heilongjong Province of northeastern China, is believed to be less prolific than the Taihu animals. ARS impored 21 Ming boars.

Ming swine reach puberty at about 4.5 months of age, average about 13 pigs in their first and second litters, and about 16 in later litters.

Solid black with long, bristly hair, Ming swine have a body type more similar to U.S. breeds and are particularly tolerant to cold.

"Even if the genes from these breeds are not used in commercial swine production, these animals can be very useful to scientists as experimental models," notes Roger J. Gerrits, ARS national program leader for animal production.

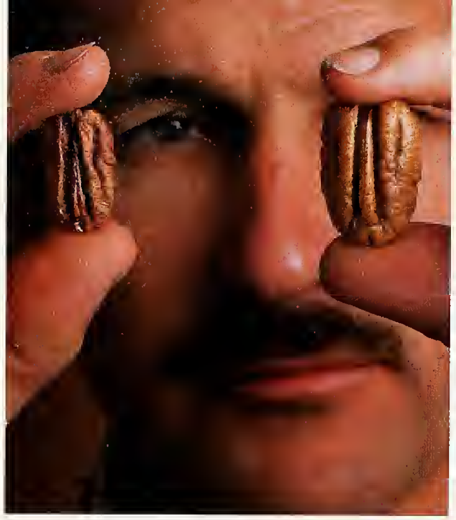
"They can be used to determine the basic physiological mechanisms that make them different from U.S. breeds.

BRUCE FRITZ

The Meishan boar, a strain of the Taihu breed, originates in the Shanghai region. (K-3382-2)

Those results help researchers better understand U.S. breeds and help establish procedures to make the U.S. breeds more productive."—By **Sandy Miller Hays**, ARS.

Roger J. Gerrits is with the USDA-ARS National Program Staff, Bldg. 005, Beltsville Agricultural Research Center, Beltsville, MD 20705 (301) 344-3066. ◆



JACK DYKINGA

Plant geneticist Tommy Thompson compares an early unimproved pecan with the latest variety to be released. (K-3317-19)

Pecan Breeders Crack a Tough Nut

To improve these favorite American nuts, start with a large measure of patience.

Pecans are true North American natives with a distinctly southern heritage, but the pecan's future is being determined in the wide open spaces of Texas.

Brownwood, in central Texas, is home to the world's only major pecan breeding station. At the W.R. Poage Pecan Field Station, some 28,000 pecan clones being evaluated promise even better pecan pies, pralines, and sticky buns for U.S. consumers.

In addition to testing new varieties, the station is also a permanent repository for old pecan varieties that are no longer propagated by the industry, notes Tommy E. Thompson, a geneticist and research leader at the Agricultural Research Service facility.

"We also keep native pecans that are continually being annihilated by land-clearing operations and construction," says Thompson. "These could be useful in the future for improving the species."

It was a Frenchman, Jean Penicant, who first noted of the name "pacane" sometime in the early 1700's. On an expedition through Natchez, an Indian settlement on the Mississippi River, Penicant described the nut along with the first recorded use of the name applied by the Indians.

Pecans were also known later as Illinois nuts, since early shipments to the Atlantic seaboard came from the northern range of pecan trees growing along the Ohio River and in the territory of the Illinois Indians. The nut's scientific name, *Carya illinoensis,* reflects this geographic origin.

But pecan breeding in the United States really got its start around 1850 at the Oak Valley Plantation near Vacherie, Louisiana. A slave gardener there, known today only as Antoine, is credited with successfully grafting 16 trees.

"Back in the 1930's, there were all kinds of production problems with pecans—how to manage them, how to fertilize them, how to prune them."

Tommy E. Thompson, ARS plant geneticist

USDA's involvement with pecans dates to 1930, when a Congressional appropriation provided for a research facility on the University of Texas campus at Austin. Prompted by a need for more orchard space, the research was moved to Brownwood in 1938.

Today, ARS' Pecan Genetics and Improvement Research encompasses 150 acres in plantings plus another 80 acres in the National Clonal Germplasm Repository.

"Back in the 1930's, there were all kinds of production problems with pecans—how to manage them, how to fertilize them, how to prune them," says Thompson. "Initially the idea was that our existing varieties were good enough, if we just knew how to manage them. Then it was decided we needed genetically improved varieties, and a breeding program was started." The USDA breeding program has yielded 16 varieties so far. "The average time it took to get each of those 16 ready to release was 23 years," Thompson notes. To develop new varieties, researchers genetically combine desirable traits from two plants by making crosses. For instance, high yield of one clone may need to be combined with disease resistance of another.

To make such a cross, researchers enclose the flowers of a pecan clone in sausage casing bags, tying the casing with string at one end. When the flowers are receptive to pollen, typically in May, the researchers apply pollen from the other plant to be used in the cross. The pollen is blown into the casing with a syringe.

The casings are removed in June, and nuts are harvested in September and October. The pecans are stored through the winter at 40°F in a bag with wet moss to maintain their

moisture content and are planted the following April.

Then begins the waiting. When the trees that sprout from the pecans begin to bear, their nut quality, insect and disease resistance, and yield are determined. At the end of a 10-year period, less than 1 percent of the trees "graduate" to the National Pecan Advanced Clone Testing System (NPACTS).

"In NPACTS, we test pecan clones with private cooperators in various parts of the country," Thompson says. "These are 15-year tests, where the cooperators grow the trees to produce the pecans. At the end of the 15 years, we look at yield data, insect resistance data, and other factors, and decide if the clone is worth releasing. We have about 180 clones in NPACTS testing right now."

Another part of the pecan genetics program at Brownwood is the National Clonal Germplasm Repository. Established about 12 years ago, it includes pecan, hickory, and chestnut varieties. Pecans are but 1 of 15 species of hickories, Thompson notes. The chestnuts are being maintained at Brownwood while scientists search for varieties resistant to the deadly chestnut blight.

When researchers hear of a promising pecan clone, they obtain samples of the nuts and compare them with information about other pecans in their files.

If the clone appears to be something new, graftwood from it is grafted onto a couple of young rootstock trees at the station, "so even if one gets wiped out, we still have the other left," says Thompson .

While Thompson and his colleagues are interested in preserving the native varieties of pecans for their genetic diversity, he has high praise for the newer, USDA-developed varieties' yield and quality.

"Some of these bear twice as much as the natives," he notes. "A good consistent yield per acre could be 1,500 to 2,000 pounds on our [USDA] varieties.

"Yield is the main thing we try to increase, but we also work to improve nut quality, nut size, and the percentage of edible nut.

"A good pecan will be 60 percent edible kernel. But the natives usually run only 45 percent."

Native pecan trees' smaller nut size is part of their plan for survival, according to Thompson.

"The natives grew in the river bottoms on alluvial soils and survived by shading out their competitor trees," he says. "The native trees might grow 150 feet tall to do that.

"But we want to dwarf the tree's growth, so the products of photosynthesis are used to produce nuts rather than wood. That's the main problem from a genetic standpoint."

In fact, traditionally pecan trees do not turn their attention to nut production until very late in the growing season, an important factor in the "alternate bearing" pattern that results in a good nut crop one year and a skimpy one the next.

"Not until August does the pecan tree begin manufacturing the oil to produce the nut," Thompson says. Pecans are about 70 percent oil by weight.

"But by the time the tree starts pulling together the oil, the days are

JACK DYKINGA

To ensure that pollen from the desired male parent is applied, the flowers of a female pecan clone are enclosed in sausage casing bags. A syringe blows pollen into the casing to ensure fertilization. (K-2128-1)

JACK DYKINGA

Horticulturist William McIlrath verifies pecan nut varieties at the National Clonal Germplasm Repository at Brownwood, Texas. Over 20,000 nut samples from pecan clones are maintained at the repository. (K-3320-15)

growing shorter and the leaves have been attacked by disease and insects all year. Because the tree's carbohydrate reserves are depleted by the nut crop, it can't replenish them in time for setting flowers the next spring. So it uses that whole next year to recuperate, and the following spring it again sets lots of flowers."

Early Maturity Sought

Researchers hope to move the pecan nut-filling period to earlier in the year. This could allow the tree to rebuild its reserves before winter and permit good flowering the next spring as well.

"Early nut-filling is a highly heritable trait," Thompson says. "We could cross two early parents and get offspring that are earlier than either parent. For example, we might cross two that have mature pecans on September 15 and get progeny that matures on September 1.

"We've already moved it forward quite a bit. Our latest release, Pawnee, has mature nuts around the first of September."

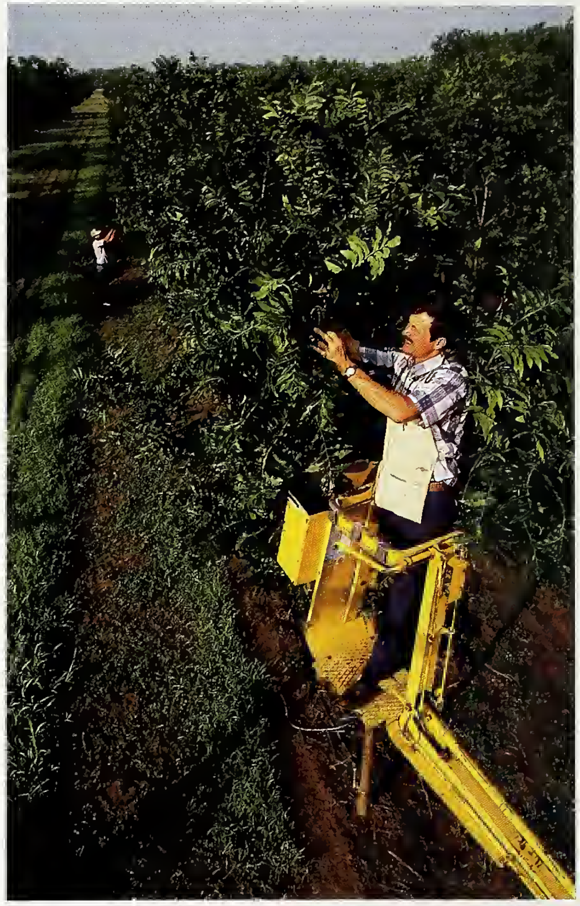
Earlier maturity means money in the bank for pecan producers in more ways than one. The peak pecan marketing season is Thanksgiving through Christmas; prices often plunge in January. Pawnee matures early enough for the prime marketing period, but many other pecan varieties miss out on the best prices.

Pecan varieties are frequently limited geographically by their level of resistance to scab, a fungal disease that defoliates trees and can cause total crop loss unless the producer uses fungicides to fight it. In Georgia, pecan producers sometimes spray as often as 10 times a year, incurring significant expense in the process.

Wichita is the most popular USDA cultivar as far as number of trees being propagated and accounts for about 8 percent of U.S. pecan acreage. But its susceptibility to scab prevents it from being grown in the East, since scab problems are proportional to the amount of rainfall and humidity in an area.

Several USDA varieties have good resistance to scab, notably Barton, Caddo, Shawnee, Cheyenne, Shoshoni, Kiowa, and the relative newcomer, Pawnee. ARS' efforts to defeat scab involve a second laboratory, the Southeastern Fruit and Tree Nut Research unit at Byron, Georgia. Besides scab, this unit also works on other pecan pest problems. [See *Blush With Death,* next page.]

ARS is also working to develop varieties with resistance to insects such as aphids. So far, Pawnee is the only USDA variety with a significant level of aphid resistance.



JACK DYKINGA

Development of pecan crosses are monitored continuously during the growing season. Tommy Thompson and research technician William Hall (on ground) check that fertilization was successful. (K-3318-8)

In addition to Wichita, Cheyenne is also a highly popular USDA pecan variety, recommended by Extension Service specialists for planting in more states than any other variety. About 14 percent of all improved commercial pecan orchards in the United States are planted with USDA varieties.

"The number would be even higher, except the pecan trees already out there live so long," Thompson says. "Stuart, an old variety that's not one of ours, has the most acreage—about 155,000 acres or 27 percent of the U.S. total." Even with the larger acreage, native pecans in 1988 accounted for only about 39 percent of the 279-million-pound U.S. production.

That there are still questions to be answered on pecans is no surprise, Thompson says: "By comparison, people have been improving walnuts by selection for thousands of years, while pecans have been selected for only about 100 years."

"Pecan breeding is an area of research that ARS serves well," he says. "We're improving a crop that no one else can afford to because of the long-range nature of the work."
—By **Sandy Miller Hays,** ARS.

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Blush With Death

At the ARS Southeastern Fruit and Tree Nut Research Station, Byron, Georgia, scientists have found a strain of the nematode *Heterorhabditis heliothidis* that is a possible biological control agent. It may help control the pecan weevil, a major insect pest of pecans from Oklahoma and central Texas through the southeastern states.

"In 1986, Louis Tedders, one of our entomologists, recovered this nematode from several reddish-colored, dead pecan weevil larvae in one of his field plots," says Andrew P. Nyczepir, a nematologist at the Byron station.

Nyczepir, along with Tedders and entomologist Jerry A. Payne, worked with ARS entomologist John J. Hamm (Tifton, Georgia) and Texas Agricultural Research and Extension Center entomologist D. Ring to uncover a possible role of the nematode in killing the weevil.

Nyczepir says that in its infective stage, as a juvenile, this nematode harbors a symbiotic pathogenic bacterium *(Xenorhabdus luminescens)* in its intestines.

"It's at this stage that the microscopic nematode enters the insect larvae—through the mouth, breathing holes, or other body openings," he says.

When the nematode reaches the host's body cavity which contains its blood supply, it releases the lethal bacteria. The host insect gets septicemia, or blood poisoning, turns red, and dies within 2 to 3 days.

It's those lethal bacteria that cause the normally cream-colored weevil larvae to turn red. During their reproductive stage, the bacteria produce a water-soluble red pigment. Although they change the weevil's color, the chemical components of the pigment are not believed to be a factor in killing the insect.

After the weevil dies, newly produced, juvenile nematodes leave the cadaver and infect other hosts. If another host is not handy, the nematodes may burrow into the soil around the cadaver. Some strains of this nematode have been reported to survive in soil for months without food.

The beneficial nematode is only about three-hundredths of an inch in size in its juvenile stage; its host, the pecan weevil larvae is about 20 times larger at three-fifths of an inch.

ANDREW NYCZEPIR

Pecan weevil on right is infected with the nematode *Heterorhabditis heliothidis.*

Small as it is, the pecan weevil cost U.S. growers about $14 million in 1987. About $9 million of this was spent on insecticides to control feeding and egg-laying adult weevils.

Nyczepir says that for biocontrol purposes the nematodes could be applied through irrigation systems or by spreading them en masse on the soil. Further studies are planned with *H. heliothidis* and other nematodes that grow in the bodies of insects.

"We want to see if the nematodes can serve as a barrier by infecting the weevil as it burrows into the soil," says Byron entomologist Michael T. Smith. His second question: Will the nematodes seek out the weevil larvae even after they have burrowed into the soil?

Smith is working with Biosys, a biological pest control company based in Palo Alto, California, that will supply the lab with nematodes for these studies.—By **Doris Sanchez,** ARS.

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Weight Loss Is Simple Arithmetic: Subtraction

November heralds the beginning of the "fat" months—those 5 months from Thanksgiving through the short days of winter when most of us eat more and exercise less. But when April rolls around and it's time to shed those extra pounds, many people will be heard to complain: "I diet and diet, and the more I diet, the more I have to diet. As soon as I go back to eating normally, I gain weight again."

"It's expected that as you lose weight, energy expenditure should decrease. Bigger bodies use more energy than smaller ones."

William V. Rumpler, ARS physiologist

To these people, ARS physiologist William V. Rumpler would say: "If you want to weigh 160 pounds, you have to eat like a 160-pounder." Unless a person has an abnormally fast or slow metabolism, he explains, it takes a specific number of calories to maintain a specific weight. His advice is based on the first findings from the Beltsville, Maryland, room calorimeter—which gives an accurate measurement of the calories a person uses throughout a 24-hour period.

In the last 2 years, some studies have suggested that cutting calories causes the body to adapt by slowing down its metabolic rate. And chronic dieting has been proposed to contribute to adaptation, as the phenomenon is known among scientists. That could explain why so many dieters complain of "hitting a plateau"—reaching a point where it becomes much harder to shed pounds.

Other studies, however, have not shown this adaptation. In both cases, the studies compared obese people or those who had lost weight with lean people, rather than looking for metabolic changes in the same person, Rumpler says.

He and colleagues in the ARS Energy and Protein Nutrition Laboratory wanted to test for adaptation under more controlled conditions. That meant putting volunteers on carefully controlled weight-loss diets and measuring the number of calories they burned before, during, and after they lost weight.

All 28 men participating in the 2 studies were healthy but overweight or, more correctly, overfat. Their body fat levels ranged from 19 to 38 percent compared with a normal range of 14 to 18 percent for men. Half of the men served as controls; in each study they were given enough calories each day to maintain their starting weights. The other half got either 25 or 50 percent fewer calories than they needed to maintain weight, depending on the study.

As the dieters lost weight, they did indeed burn significantly fewer calories, says Rumpler, but the drop was no greater than would be expected from reducing the amount of food they had to process. "Between 8 and 15 percent of the calories we eat are lost as heat" as the body digests, absorbs, converts, and stores nutrients from a meal, he explains.

About 90 percent of the drop in the men's energy expenditure came in the first week of the weight-loss diets,

FRED WARD

Confined to the room calorimeter in Beltsville, Maryland, a study volunteer receives a precisely measured meal from lab technician Laura Kressler. (K-3326-3)

and most of that was on the first day—too soon for the metabolism to gear down.

The men eating 25 percent fewer calories used 6 percent less energy at the end of the first week; those eating 50 percent fewer calories used 8 percent less. When this latter group resumed eating their normal number of calories 4 weeks later, their energy expenditure returned almost to its starting level.

"We didn't see any adaptation in either study," says Rumpler. The men's energy expenditure dropped proportionally to the amount of weight they lost.

"It's expected that as you lose weight, energy expenditure should decrease. Bigger bodies use more energy than smaller ones."

It takes state-of-the-art instrumentation to track every calorie a volunteer burns throughout his day. Physiologist William Rumpler (right) and biomedical engineer Jim Seale monitor the carefully controlled study. (K-3325-6)

The findings are supported by a recently published study done under similar controlled conditions. The age-old complaint of dieters—that they lose the first few pounds quickly and then stop losing—doesn't have to happen, says Rumpler. "Our data show that if you continue to reduce calories, you will continue to lose weight."

For example, people who lose 10 percent of their body weight need 10 percent fewer calories to remain at their new weight. To lose more, they have to continue reducing their intake to the number of calories necessary to maintain their target weight.

The problem, he suspects, is that "after people have been on a diet for a while, they begin to eat more than they think they're eating." His own experience with study participants is that they substantially underestimate the number of calories they consume. "People may get a salad for lunch, thinking it's low in calories. But by the time they add croutons, cheese, bacon bits, and smother it in oil or dressing, it has more calories than my peanut butter and jelly sandwich."

Rumpler and colleagues also wanted to know if the level of dietary fat had any effect on the number of calories the men burned. Other studies, including an earlier one done at the Beltsville laboratory by Joan M. Conway, have shown that people lose more body fat (but not necessarily more weight) simply by replacing part of the fat calories in their diets with carbohydrate calories.

So half the men in the second study got a low-fat diet (20 percent fat calories) for 4 weeks while the other half got a high-fat diet (40 percent fat) containing the same number of calories.

There was no significant difference in energy expenditure or body fat loss between the two groups, says Rumpler. "What we found is that a calorie is a calorie," regardless of its source.

This was not entirely consistent with Conway's findings, Rumpler concedes. "We thought that the men on the low-fat diet would lose more body fat—not weight," he says. However, the women in Conway's study consumed a low-fat diet for 4 months. Rumpler's 4-week study may have been too short to see an effect of dietary fat on body fat.—By **Judy McBride,** ARS.

William V. Rumpler is at the USDA-ARS Beltsville Human Nutrition Research Center, Bldg. 308, BARC-East, Beltsville, MD 20705 (301) 344-4360. ◆

Breeding Super Sweetpotatoes

Regal, Southern Delite, and Excel, new sweetpotato varieties bred by ARS researchers at the U.S. Vegetable Laboratory in Charleston, South Carolina, produced more marketable potatoes without insecticide than did Jewel and Centennial when they were sprayed regularly.

Jewel, the current queen of commercial varieties, is the standard against which new varieties are usually measured.

"There are naturally occurring chemicals in the skins of sweetpotatoes that inhibit seed germination and root formation of many common weeds and that interfere with nematodes and insects."

Joseph Peterson , ARS plant physiologist

"And when you treat them all equally with insecticide as some growers do anyway, Regal, Southern Delite, and Excel do even better," says plant pathologist Philip Dukes, who helped develop the new varieties. "In one trial conducted as an outside verification at Mississippi State University, Southern Delite produced five times the U.S. No. 1 quality yield of Jewel when they were both treated with insecticide."

Excel—the newest of the three varieties, having become commercially available just this season—has unusually strong resistance to seven common soil insect pests: southern potato wireworm, tobacco wireworm, banded cucumber beetle, spotted cucumber beetle, elongated flea beetle, palestriped flea beetle, and sweetpotato flea beetle. It also has high levels of resistance to the white grub and southern root knot nematode. "Resistance in Excel amounts to 80-percent control of the soil insects, 75 percent of the sweetpotato flea beetle, and 92-percent control of

ROB FLYNN

Plant pathologist Phillip Dukes proudly displays new varieties of sweet potatoes (left to right) Southern Delite, Regal, Excel, and Sumor, bred by ARS researchers at the U.S. Vegetable Laboratory in Charleston, South Carolina. (K-3393-16)

the white grub," says geneticist Alfred Jones, who also worked on the project. "That's control you just cannot achieve with the presently recommended chemical treatments."

Excel's resistance to nematodes has another potential benefit, according to Jones. He points out that since growing Excel reduces the nematode population in a field, growing it means farmers might not have to treat the following crop with a nematicide even if it's a susceptible crop.

Sweetpotatoes may also one day be able to share their resistance with other plants, providing natural biological insecticides, according to plant physiologist Joseph Peterson at the same lab, who succeeded in isolating the chemicals that account for most of the anti-weed and anti-insect activity.

"There are naturally occurring chemicals in the skins of sweetpotatoes that inhibit seed germination and root formation of many common weeds and that interfere with nematodes and insects," Peterson says. "In the pure form, at least one of them may be as potent as some of the commercial herbicides and insecticides used today."

The compounds responsible for nematode resistance would be of special interest because so many commercial nematicides have recently been taken off the market, Peterson points out.

"With more than one compound involved, there are likely to be several different mechanisms at work for both weed resistance and insect resistance," he says. "This is really to the good because it will make it more difficult for the insects and weeds to build up tolerance."

One day, growers might be raising industrial-strength sweet-potatoes for the insecticide and herbicide market.

Turned On To Tubers?

For many Americans, the sweetpotato is traditional holiday fare, but our annual per capita consumption of the tubers is a mere fraction of that of conventional spuds—4.4 pounds, as opposed to 127.3 pounds of white potatoes.

Despite our seasonal appetite, sweetpotatoes ranked 15th among U.S. crops in dollar sales by growers in 1988.

Sweetpotatoes were planted in Virginia in the mid-17th century. Since then, they've spread across the southern tier of states and up the east coast to New Jersey.

In 1988, the top two producing states, North Carolina and Louisiana, harvested more than half of the 1.1 billion pound crop.

Resistance to insects, weeds, and diseases are not the only characteristics bred for at the lab. They also breed for sweetness, flavor, and even color.

Among other developments, Dukes has come up with a variety that has white meat with a flavor very like that of an Irish potato.

The variety is named Sumor, which is Old English for summer, because it still has sweetpotato's liking for heat.

Where the climate is too hot to grow Irish potatoes, Sumor would make a good substitute as a crop and on the table, says Dukes.

"I made potato salad out of Sumors for a family reunion, and no one suspected that it was made with sweetpotatoes," he says. Sumor also whips into perfect mashed potatoes, he adds.

Oddly enough, when they first form underground, Sumor sweetpotatoes start out yellowish orange. As they near harvest, the color changes from yellow to cream and may fade to white by the time they are mature.

While Sumor has only a fraction of the vitamin A found in typical orange sweetpotatoes, it has more vitamin C then do most tomatoes. "That makes Sumor qualify as a high-nutrition crop," Dukes says.

Sweetpotatoes rank number 3 in nutritional value among vegetables, according to the North Carolina Sweetpotato Commission.

Seed of Sumor sweetpotatoes is commercially available from Foundation Seed, Inc., at Clemson University.

Another new sweetpotato recently released as a parental breeding line is DW-8. This is a dwarf vining sweetpotato with small leaves and short spaces between leaves, according to Jones.

"Dwarf vines won't overgrow the rest of the garden like sweetpotatoes tend to," Jones says.

While the line can yield as much as 95 percent of Jewel, the sweetpotatoes it produces are a little too fibrous for the line to be used as it is. But plant breeders may find it useful for their development programs so we released anyway," Jones says.—By **J. Kim Kaplan,** ARS.

Philip Dukes, Alfred Jones, James M. Schalk, and Joseph Peterson are with the U.S. Vegetable Laboratory, 2875 Savannah Highway, Charleston, SC 29414 (803) 556-0840. ◆

The Cheese Detectives

When the U.S. Customs Service suspected last year that some imported cheese being sold in this country as "Cheshire" was actually cheddar, they turned to chemist Michael H. Tunick of the Agricultural Research Service.

Tunick, who is with ARS' Eastern Regional Research Center in Philadelphia, is a specialist on the finer properties of cheeses.

Tunick, with colleagues Edward J. Nolan, James J. Shieh, Marvin P. Thompson, Beverly E. Maleeff, and Jay J. Basch, began the detailed analysis of the suspect cheese in August 1988 by first examining physical and chemical properties of bona fide Cheddar and Cheshire cheeses.

Cheshire cheese is an English cheese that closely resembles cheddar. Although both cheeses are similar in price, consumers could be deceived by the mislabeling.

One way to check cheese identity is with scanning electron microscopy, which magnifies the structure of protein and fat components. For example, Tunick says fat droplets in Cheddar cheese are larger and proteins are denser than those found in Cheshire cheese.

Cheese samples are also checked by electrophoresis, which measures protein movement when an extract of cheese is placed in an electric field.

"The distance they travel in the electric field is a fingerprint of the proteins in cheese," Tunick says.

Tests showing the most noticeable differences in cheese involve rheology, or study of the flow of matter. In these tests, Tunick measures elasticity and fluid properties of cheese.

Tunick says Cheshire cheese will crumble more readily than Cheddar cheese when placed under strain.

These tests confirmed Customs' suspicion: the cheese was not genuine English Cheshire.

In another case, a differential scanning calorimeter measuring how much fat melts in natural Mozzarella cheese helped lead to last year's conviction of a midwestern cheese company for selling fake Mozzarella cheese. The cheese actually contained calcium caseinate, a chemical derived from milk and used to make imitation cheese.—By **Bruce Kinzel**, ARS.

Michael H. Tunick is at the USDA-ARS Milk Components Utilization Research Unit, Eastern Regional Research Center, 600 East Mermaid Lane, Philadelphia, PA 19118 (215) 233-6703. ◆

Catfish Disease: A Step Closer to Control

It's a classic case of taking the lemons life hands you and making lemonade.

Agricultural Research Service scientists have found a way to use part of a bacterium deadly to catfish to help diagnose and perhaps even protect the fish against that same bacterium when it strikes.

The culprit is *Edwardsiella ictaluri,* and it is estimated to be at the bottom of up to 40 percent of all catfish diseases in the Southeastern United States.

"*Edwardsiella ictaluri* causes enteric septicemia," notes microbiologist Phillip H. Klesius, the research leader at ARS' Animal Parasite Research Unit at Auburn, Alabama. "Mortality can run more than 50 percent."

The bacterium survives in pond mud, most frequently appearing when water temperature is between 64° and 82°F.

Other prime conditions for an outbreak include poor water quality, large numbers of fish in the pond, or some form of stress on the fish. Fish from fingerlings to adults can fall prey, but the bacterium seems to hit hardest the pound-to pound-and-a-half fish—those prime for marketing.

The fish producer's only defense in the past has been to use antibiotic-dosed feed.

But that pushes up production costs, and farmers have had no way of knowing for certain when an outbreak is imminent and the more expensive feed would be needed.

The guessing game—with its subsequent production losses—has cost fish farmers $10 million annually, Klesius estimates.

Now, however, a new weapon has been discovered to help win the economic battle against *E. ictaluri.*

"We've found a protein from *Edwardsiella,*" says Klesius. "We can take blood from a representative sample of the fish in the pond, mix the blood with this protein, and

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Healthy channel catfish.

tell if the fish have the disease." At that point, the producer could start medicated feeding in time to prevent a serious outbreak. He says, "In the past, all we could do was look for the organism in dead fish."

"This [protein discovery] could also have vaccine potential, maybe within 3 to 4 years," Klesius says. "But we should be ready to use it commercially for diagnosis by next year."

The research to test the protein is being done in cooperation with John Plumb, professor of fisheries and allied aquaculture at Auburn University, and Robert Durborow, fisheries specialist with the Mississippi Cooperative Extension Service at Stoneville, Mississippi.—By **Sandy Miller Hays**, ARS.

Phillip H. Klesius is in USDA-ARS Animal Parasite Research, P.O. Box 952, Auburn, AL 36931-0952 (205) 887-3741. ◆

Patents

Neckbands—An Alternative to Ear Tags

Cattle have swallowed pills, carried implants, and worn ear tags to protect them from biting horn flies, face flies, ticks, and mites. Soon they may wear neckbands, the newest weapon in the battle to control insecticide-resistant horn flies.

"It's an alternative to ear tags," says J. Allen Miller, ARS agricultural engineer at the Knipling-Bushland U.S. Livestock Insects Research Laboratory in Kerrville, Texas.

In the mid-1970's, when they were first commercialized, ear tags immediately won ranchers over because they were both economical and effective. But within 2 to 3 years after they appeared on the market, flies began to develop resistance, says Miller.

Heavy reliance on the ear tags and the class of insecticides they delivered—pyrethroids—may have inadvertently helped horn flies become resistant. "One way to manage resistance is to switch to a class of insecticides that has a different mode of action," says Miller.

Organophosphates appear to be a good choice because flies are not known to be resistant to them. However, they are less toxic and may degrade faster than the pyrethroids, so larger amounts are needed.

Miller says neckbands are a good delivery method for this class of insecticides. As with ear tags, the neckbands provide a good alternative to spraying because chemicals are targeted to the animal's hair coat.

"It's a device within a device," says Miller, referring to a polymerized plastic reservoir that holds the insecticide inside the neckband. The insecticide is released from the neckband by contact with the animal's hair.

As easy for cattle to wear as ear tags, the neckbands offer another advantage. The reservoir can be refilled by including a removable plug or cap; or ranchers may prefer to remove the neckband and discard it at the end of the insect infestation season.

In addition to the horn fly, organophosphates are effective against face flies; mange mites; the screwworm fly; and the Gulf Coast, lone star, and southern cattle ticks.

In field trials, the neckbands holding chlorfenvinphos provided 91-percent control of horn flies. Diazinon delivered by the neckbands provided 88-percent control.

Horn flies alone annually cost cattle producers about $700 million in reduced weight gains and lowered milk production for nursing calves. Ticks account for an added $275 million in losses.—By **Linda Cooke,** ARS.

For technical information, contact J. Allen Miller, USDA-ARS, U.S. Livestock Insects Research Laboratory, Kerrville, TX 78029 (512) 257-3566. Patent Application Serial No. 07/226,057 "Device for Sustained-Release of a Chemical Onto an Animal and Method of Using the Device." ◆

Correction

The article describing the work of ARS ecologist Jane L. Hayes and postdoctoral associate Michael Firko, on sibling analysis [*Agricultural Research*, October 1989 was erroneously referred to as a population genetics tactic. Dr. Hayes describes this work as quantitative genetics.

The article also inadvertently omitted a fuller explanation of quantitative genetics.

Drs. Hayes and Firko are using methods developed in quantitative genetics to study resistance. This approach calls for comparing multiple-sired insect siblings to each other or parents to offspring, which exposes genetic relationships and forces the expression of the resistance trait if it is present in a population.

Using the quantitative genetic approach, only the expression of the trait is important—not how many genes are involved, which would be more of a concern in the commonly used methods of insect population genetics. The quantitative genetics approach can be very labor intensive and requires that the insects cooperate by mating upon request, but the benefit of this approach is the provision of predictive information, which is described in the article.

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